Grand Glaize Bridge
Spanning the Lake of the Ozarks
U.S. Route 54
Osage Beach
Camden County
Missouri

HAER No. MO-79

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

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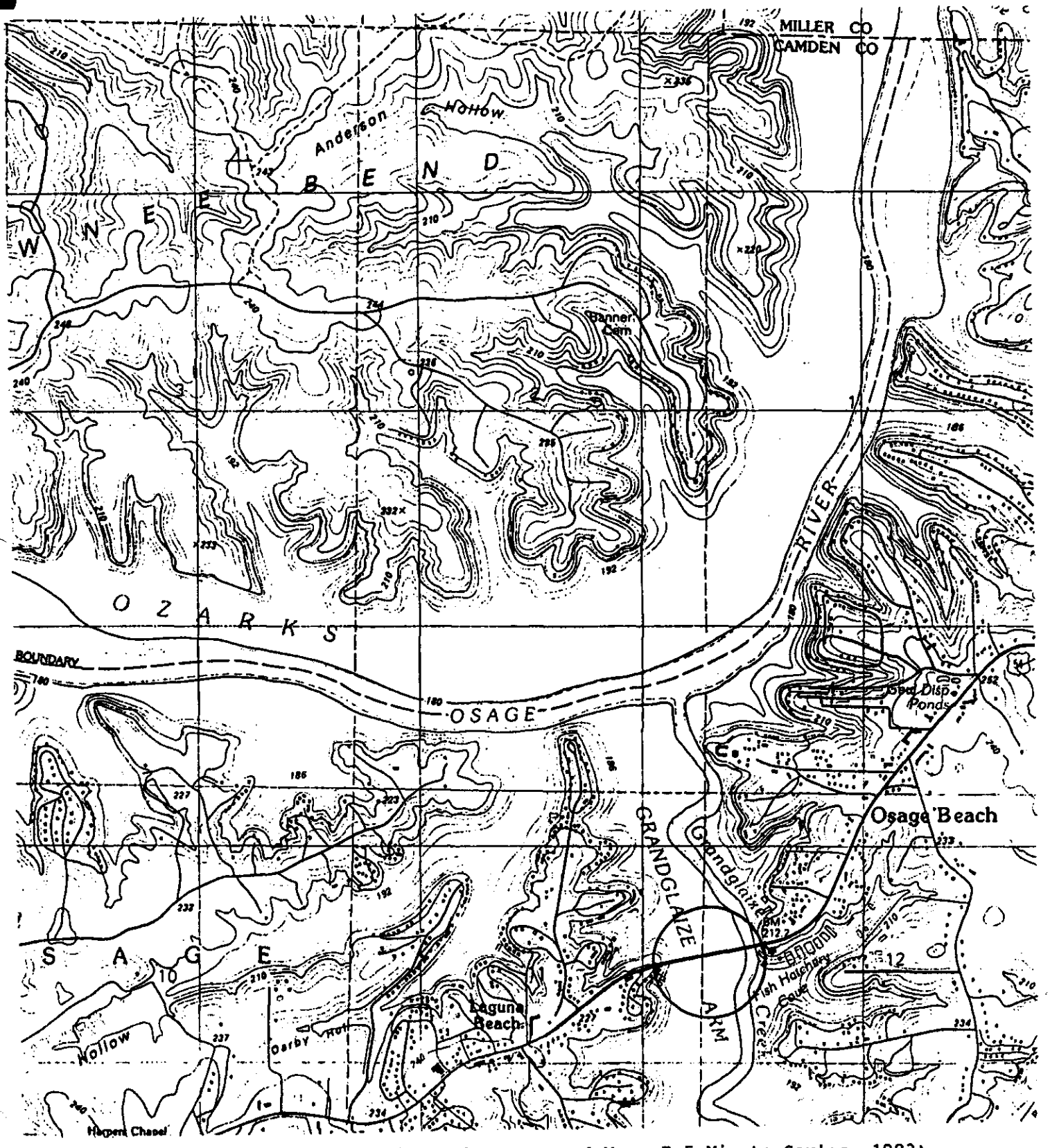
HISTORIC AMERICAN ENGINEERING RECORD

HAER No. MO-79

GRAND GLAIZE BRIDGE

I. Introduction

Location:	Spanning the Lake of the Ozarks, Grand Glaize Arm, Osage Beach, Camden County, Missouri
Quad	Lake Ozark (7.5 Minute)
UTM	A 15/4220540/531520 B 15/4220450/531060
Construction Date	1930-1931
Present Owner	Missouri Highway and Transportation Department
Present Use	Abandoned vehicular bridge to be removed and replaced by a new vehicular bridge. Projected date of removal is spring 1994.
Significance	The Grand Glaize Bridge, designed by Sverdrup and Parcel, Consulting Engineers of St. Louis, is one of three cantilevered deck trusses in Missouri. Built in preparation for the Lake of the Ozarks, a vast reservoir impounded behind Bagnell Dam, the Grand Glaize Bridge and a new section of U.S. Route 54 allowed this formerly remote region to open for tremendous tourist development.
Historians	Stacy Sone, Architectural Historian, and David Austin, Historian, Cultural Resources Section, Design Division, Missouri Highway and Transportation Department, Jefferson City, December 1993.



Location Map (Lake Ozark, Missouri, USGS Quad Map; 7.5 Minute Series, 1983).

II. History

A. Need for the Bridge

Before the Union Electric Power Company began constructing the great Bagnell Dam across the Osage River in Miller County, the area was sparsely settled and contained only a few scattered communities and farms. Two decades after Lewis and Clark explored this part of the Ozarks, pioneers from Virginia, Kentucky, and Tennessee settled and established farms in the fertile Osage River valley.[1] The Osage River meandered across the entire northern section of Camden County and across Miller County but was partially navigable only for light cargo vessels. Since it was not a first-class waterway, the river did little to invite commercial and industrial development and it remained a neglected natural resource. Toward the end of the nineteenth century, thousands of acres of ridge and table lands in Camden and Miller counties were still vacant and available for settlement.[2]

The low population and lack of development along the Osage River attracted the attention of the Missouri Hydro-Electric Power Company of Kansas City which considered constructing a dam

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1. Carolyn Callison, "The Great Lake of the Ozarks Was Just a Small River Fifty Years Ago," The Midwest Motorist (March-April 1980), pp. 8-9 (copy in Lake of the Ozarks, Miller County file, Cultural Resources Inventory, Missouri Department of Natural Resources, Jefferson City).

2. History of Laclede, Camden, Dallas, Webster, Wright, Texas, Pulaski, Phelps, and Dent Counties, Missouri (Chicago: The Goodspeed Publishing Company, 1889; reprint, 1974), pp. 281, 296, 318.

across the river as early as 1911. The company conducted no extensive feasibility or engineering studies until the early 1920s and by then, financial complications forced these original planners to sell the land they had acquired to the more powerful Union Electric Company. Union Electric planned to build a massive dam that would supply the tremendous amount of electrical energy demanded in St. Louis and other communities in Missouri, Illinois, and Iowa.[3]

The onset of the Great Depression allowed Union Electric to easily secure over 4,000 willing laborers from across the United States to build the dam. Because of the lack of facilities in the area, the company built an entire community to accommodate these workers and their families before the actual dam construction was underway. This model town included houses, dormitories, dining halls, a commissary, fire department, school, jail, hospital, and power plant. In addition to building the community, Union Electric constructed bridges and railways to access the dam site and a gravel plant to mix the tons of concrete necessary for the massive structure.[4]

Construction of Bagnell Dam began on August 6, 1929, under the direction of the Stone and Webster Engineering Corporation from Boston. With steady shifts of carpenters, concrete workers,

3. Callison, 9; "Bagnell Dam, Erected in 18 Months, Celebrates its 50th Year of Service", Bagnell News, 1981; "Story of the Great Osage Dam," Missouri Magazine 4 (June 1931), 9.

4. "Bagnell Dam," From These Beginnings: Ozarks Past, (Camdenton, Missouri: Lake of the Ozarks Council of Local Governments, n.d.), p. 26; "Story of the Great Osage Dam," 8.

and general laborers working around the clock, the project progressed quickly until the giant dam was completed. In February 1931, the dam gates closed forcing the Osage River to back up and form a reservoir. Upon the dam's completion, a writer for the Missouri Magazine boasted that the structure

> ...is a monolithic of concrete and steel, flung with bewildering speed and skill across the Osage River...It stands as a monument of the courage and vision of men, an awe-inspiring engineering triumph, impressive and majestic through its 2543 feet of length.[5]

An essential component of the dam operation was the vast reservoir that the power plant demanded to generate electricity. The company conducted an extensive study to determine the Osage River's flow and how large a pool the power plant would require to operate the powerful water wheels. Studies concluded that the hydro-electric plant demanded a reservoir covering 60,000 acres with a 1,300 mile boundary.[6]

The dam brought about dramatic changes in the area that required consideration during the early planning phase. Alterations in the terrain caused by the impounded water and the anticipated tourist flow forced Union Electric to build new bridges and roads to replace those that would be flooded. Wise planning by the Missouri State Highway Commission and Union

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5. "Interest in Figures About Osage Dam and Lake of the Ozarks," The Eldon Advertiser, November 27, 1930; "Bagnell Dam," From These Beginnings, p. 27; "Story of the Great Osage Dam," p. 7.

6. "Story of the Great Osage Dam," p. 8; "Before Reservoir Filled, Land Was Cleared," Bagnell News, 1981; R.W. Selvidge, "Lake of the Ozarks Project," Missouri Magazine 6(May 1934), 28.

Electric officials allowed U.S. Route 54 to be re-routed over the top of the dam when completed providing direct access to the future vacation destination.[7]

The electric company conducted a critical preliminary study to determine how high the water would rise once the dam gates closed and it established a maximum 660 foot water elevation. Sections of U.S. Route 54 traversed near enough to the Osage River channel and its tributaries that, once the reservoir filled, the water would cover the road and some bridges. The Route 54 bridge spanning the mouth of the Grand Glaize Creek at the Osage River would be completely submerged even at the minimum 620 foot water level. The future reservoir required that the Union Electric Company build a new Grand Glaize crossing and construct a section of Route 54 to access the bridge.

When the Union Electric Company and the Missouri State Highway Department planned the Grand Glaize Bridge, there was no public demand for the new crossing. The existing bridge had been built only a few years before and was perfectly adequate for handling the traffic across the narrow Grand Glaize Creek. Union Electric moved ahead with the new bridge construction understanding that it would be much easier and less expensive to build the bridge before the reservoir filled. A location near Zebra, about two miles south of the old bridge, was chosen for the new Grand Glaize crossing. On June 18, 1929, Union Electric

7. "The Old Steps Aside for the New," Missouri Magazine 3 (August 1930), 11; "Highway 54 to be Slabbed Is on Program," The Eldon Advertiser, January 23, 1930.

entered into contract with the Missouri State Highway Commission to build the new bridge.[8]

B. Construction Chronology

The Union Electric Company provided all funding for the relocated Route 54 and the Grand Glaize Bridge. Stone and Webster Engineering, which supervised the dam construction, also was placed in charge of the new bridge and acted in cooperation with the Missouri State Highway Department. In 1929, before the dam construction was underway, Union Electric awarded the contract for the Grand Glaize Bridge design to Sverdrup and Parcel, Consulting Engineers of St. Louis.[9]

In August 1929, the designers submitted their preliminary plans for the Grand Glaize Bridge to Stone and Webster and to the highway department. The engineers designed the 1,630 foot long bridge in an unusual configuration with the trusses underneath the deck warranting the nickname, "upside down bridge". A design such as this would afford travelers an unimpeded lake view in

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8. "Story of the Great Osage Dam,", p. 9; "Diagrammatic Sketch Showing Approximate Relative Elevations at Existing Grand Glaize Bridge," Missouri State Highway Department (M.S.H.D.), Grand Glaize Bridge No. J-832 File, (Jefferson City: Bridge Division, Missouri Highway and Transportation Department), March 29, 1930; "Approval of Resolution Accepting the Bridge Over Grand Glaize Creek and Concerning Parts of U.S. 54," Missouri State Highway Commission, Minutes of Proceedings, January 14, 1931 (Jefferson City: Secretary's Office, Missouri State Highway Commission).

9. Highway Commission Minutes, January 14, 1931; M.S.H.D., Grand Glaize Bridge No. J-832, File.

this exceptionally scenic setting.[10] By November, Sverdrup and Parcel, in consultation with Stone and Webster and the Missouri State Highway Department, had revised their design slightly and were ready to present it for consideration at a public hearing.[11]

In January 1930, Sverdrup and Parcel delivered their final bridge plans to the State Highway Department after making several changes in the design.[12] Highway department Bridge Engineer, N. R. Sack responded with critical comments regarding the substructure. He determined that bent number 2 would not be stable under longitudinal wind forces because it fell outside the middle half of the base. He also claimed that the bases of piers 4, 6, and 7 were unstable and that the shafts of these piers were over-stressed.[13] Mr. Sack offered suggestions to remedy these inadequacies but in a reply, Sverdrup and Parcel stated that their design principles were identical to Mr. Sack's but they differed in the assumptions made. Mr. Sverdrup explained their plans at length and defended the original design.[14] After both

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10. M.S.H.D., Bridge No. J-832 File, L. J. Sverdrup to N. R. Sack, August 23, 1929; Carole Tellman Pilkington, The Story of Bagnell Dam, (Osage Beach, Missouri: Lake Area Chamber of Commerce, n.d.), p. 12.

11. M.S.H.D., Bridge No. J-832, File, Public Hearing Notice, November 9, 1929.

12. Ibid, E. R. Grant (for Sverdrup and Parcel) to N. R. Sack, January 14, 1930.

13. Ibid, N. R. Sack to Sverdrup and Parcel, January 16, 1930.

14. Ibid, L. J. Sverdrup to T. H. Cutler, January 25, 1930.

parties compromised considerably, the Missouri State Highway Department approved the final plans.[15]

While Sverdrup and Parcel worked out details with the highway department, the designers awarded the general construction contract to the Pioneer Construction Company from Kansas City. The C. P. O'Reilly Construction Company received the contract for the bridge approaches and Stupp Brothers Bridge and Iron Company was awarded the contract for the superstructure.[16]

The Grand Glaize Bridge construction began in March 1930, and proceeded rapidly with a workforce of forty to fifty men borrowed from the dam project. Most of the equipment arrived at the site by way of the railroad spur leading to the dam and then it was hauled to Grand Glaize Creek a short distance away.[17] O. D. Chrisman, General Inspector for the State Highway Department, inspected the bridge during construction in May 1930, and noted that the Pioneer Construction Company had completed the abutments, referred to as bent numbers 1, 2, 9, and 10. On the same date, the work crew poured the concrete for pier number 3 and had begun the excavation for pier number 4. Chrisman noted that the job was well equipped and would make exceptionally rapid

15. Ibid, N. R. Sack to Sverdrup and Parcel, February 12, 1930.

16. Ibid, "Tabulation of Bids"; "Contracts Let for Bridge Over Grand Glaize Creek," The Eldon Advertiser, January 30, 1930.

17. "Highway Changes Begin in Reservoir Area of Osage Dam," The Eldon Advertiser, May 15, 1930; "Work to Start on Approaches to Bridge at Zebra," The Eldon Advertiser, March 6, 1930.

progress.[18] Two weeks after the inspection, The Eldon Advertiser reported that the bridge approaches, constructed under the supervision of C. P. O'Reilly Construction Company, were half completed and that the steel for the superstructure would be delivered to the site any day.[19]

The next bridge inspection occurred in late June 1930. State Highway Department inspector D. C. Wolfe, accompanied by H. F. Duckworth of the Pioneer Construction Company, reviewed the progress and reported that the substructure was 67 percent complete and the approaches 62 percent complete. The structural steel for the superstructure had been delivered to the site and would be ready for placement as soon as Pioneer Construction finished the substructure around the middle of August. Mr. Wolfe was pleased with the workmanship and rapid progress and estimated that the entire project would be completed by November 1, only eight months after construction started.[20]

Stupp Brothers Bridge and Iron Company began placing the steel for the Grand Glaize Bridge superstructure on schedule in August 1930. By the middle of October, they had completed two of the five main spans. The entire project was finished sometime in

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18. M.S.H.D., Bridge No. J-832 File, O. D. Chrisman to Mr. Levi, May 6, 1930; "An Immense Bridge at Grand Glaize," The Eldon Advertiser, April 24, 1930.

19. "Highway Changes Begin in Reservoir Area of Osage Dam," The Eldon Advertiser, May 15, 1930.

20. M.S.H.D., Bridge No. J-832 File, Inspection Report, June 24, 1930.

November except for the paint which was scheduled to be applied during the next spring.[21]

D. C. Wolfe inspected the structure again upon completion and noted several criticisms on the roadwork leading to the bridge. He claimed that the road was in good condition when finished several months before but it had deteriorated while the bridge project was underway. Wolfe offered several suggestions for repairing the roadwork and demanded that the contractor correct minor details before the state assumed control of the bridge. He tested the bridge floor at various speeds and observed that it was an excellent riding surface unequaled on any bridge in the state.[22] On January 9, 1931, the Missouri State Highway Department notified the Union Electric Company that the Grand Glaize Bridge had been approved except for painting. During a January 14, 1931, State Highway Department meeting, the commission officially abandoned old Route 54 and accepted the new route, including the Grand Glaize Bridge, in its place.[23]

The Grand Glaize Bridge opened to traffic without ceremony or demonstration in January 1931. Upon its completion, a writer for the Versailles Statesman boasted that the bridge is

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21. "Steel For Highway Bridge Over Osage Dam On Hand Ready," The Eldon Advertiser, September 4, 1930.

22. M.S.H.D., Bridge No. J-832 File, "Inspection Report on Grand Glaize Relocation on U.S. 54, Camden County," December 23, 1930.

23. Ibid, L. J. Sverdrup to T. H. Cutler, April 15, 1931; Highway Commission Minutes, January 14, 1931.

> ...a striking feat of engineering and construction. Resting nearly 150 feet above the valley of the Glaize, which soon will be buried under 100 feet of water from the Lake of the Ozarks, the new bridge is impressive and rather breathtaking when you first venture upon it.

With the completion of the bridge, the area was prepared for the flood of tourists expected once the reservoir filled. The Eldon newspaper advertised that the bridge was located at one of the most picturesque places along the new Route 54 and extended over "a wide area with abundant scenery on all sides." The modern construction, leaving the superstructure under the roadway, allowed visitors to absorb the exceptional scenery whether passing through the area or vacationing there.[24]

The Grand Glaize Bridge served millions of travelers during the next few decades. By the late 1960s, with an increase in traffic volume, the Missouri State Highway Department determined that the bridge was no longer adequate and needed to be replaced or used in conjunction with a new bridge.[25] A 1971 inspection revealed that the bridge floor, structural members, and the pier caps were in poor condition. The Maintenance and Traffic Division of the Missouri State Highway Department recommended that the structure not be retained for an alternate route or as part of a dual bridge facility.[26] The highway department

24. "Grand Glaize Bridge a Scenic Place," The Eldon Advertiser, February 19, 1931; "Over Striking Bridge," The Versailles Statesman, February 26, 1931.

25. M.S.H.D., Bridge No. J-832 File, Bridge Engineer to R. N. Hunter, December 19, 1966.

26. Ibid, K. C. Townley, to James F. Roberts, November 19, 1971.

continued to maintain the Grand Glaize Bridge until a new crossing was constructed adjacent to it during the 1980s. The old bridge was abandoned in 1985 when the current bridge was completed. Even after it closed to traffic, the Grand Glaize Bridge did not stand unnoticed. The Lake Ozark Community Betterment Association strung the bridge's railings with hundreds of lights at Christmas. More recently, a display of Santa Claus skiing behind a speedboat decorates the old bridge and entertains travelers crossing the current bridge.[27]

C. The Grand Glaize Bridge and Tourism at the Lake of the Ozarks

In October 1931, the dam commenced operation forcing the construction crew to move on to other projects. With a reservoir nestled into one of the Midwest's most scenic regions and a major U.S. highway linking it from across the state, the stage was set for tremendous development that surely would forbid the area to return to its former quiet wilderness. The Lake of the Ozarks, named before the dam was even completed, would become the nation's largest man-made lake. Far-sighted promoters of the area quickly recognized the exceptional recreational potential that this 129 mile reservoir, lined with hundreds of picturesque coves and inlets, would provide. Even before the lake formed, the dam itself attracted thousands of tourists during its

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27. Nicki Foster, Chairman, Lake Ozark Community Betterment Association, telephone conversation with Stacy Sone, Missouri Highway and Transportation Department, December 14, 1993.

construction. More than 200,000 people had traveled to the site by May 1, 1931 with almost 8,000 visiting on a single day. This phenomenal tourist flow provided only a hint of what the area could expect once the lake formed.[28]

While the reservoir filled during the spring 1931, the Versailles Statesman expected that the lake would become the state's largest summer resort area within the next few years and would entice visitors not only from across Missouri but from all the Midwestern states.[29] Ideally located in the center of Missouri and the United States, the lake in its exceptionally scenic Ozark setting lended itself perfectly to the tourist industry. The writer's predictions proved correct a few years later when businesses geared to vacationers became established on sections of the lake's irregular shoreline.[30]

One of the earliest efforts to accommodate lake-area tourists was the establishment of a town called Osage Beach. Strategically located on U.S. Route 54 only two miles from the dam, the area was chosen for its accessibility and scenic setting. Real estate promoters planned the resort community to include a business and residential section with parkways

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28. R. W. Selvidge, "Lake of the Ozarks Project," Missouri Magazine 6(May 1934): 28-29; Harland Bartholomew, "State Parks on the Lake of the Ozarks," Missouri Magazine 5(October, 1933), 5; "Development of New Summer Resort Area Begun at Osage Dam," The Versailles Statesman, March 12, 1931; "Story of the Great Osage Dam," p. 8, 11; "Bagnell Dam," From These Beginnings, p. 27.

29. "Development of New Summer Resort Area."

30. "Story of the Great Osage Dam," 11; Selvidge, 28-29.

throughout, "to be worked out along line of beauty, with every modern convenience." Unfortunately, the Great Depression prevented Osage Beach from becoming the resort community that the original developers had planned. The community grew regardless as entrepreneurs established a variety of businesses in this prime location. Tiny Zebra, which only contained a post office and store, became part of Osage Beach during the 1940s.[31]

The newly completed highway system, including the Grand Glaize Bridge, allowed the area to transform into a major Midwestern tourist destination. The improved roads provided convenient access to the Lake of the Ozarks from all parts of the state.[32] An enthusiastic writer for the Missouri Magazine anticipated in 1934 that

> ...thousands of tourists from North, South, East and West will come to be charmed by glimpses of the Ozark's everchanging beauty. Other thousands who seek rest and health will find new vigor and peace of mind in its health-giving climate. When its convenient central location to all Missouri, with improved highways leading to and from all directions, the Lake of the Ozarks lends itself splendidly as an ideal location for cabins, lodges, summer homes, and resorts and is destined in a very short time to be the mecca for thousands who seek the communion of Nature and enjoyment of the great outdoors.[33]

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31. "The Old Steps Aside for the New," p. 11; Writers' Program of the Works Projects Administration, Missouri: A Guide to the "Show Me" State (New York: Duell, Sloan and Pearce, 1941; reprint, The WPA Guide to 1930s Missouri, Lawrence: University Press of Kansas, 1986), p. 565.

32. "Relocating of Highways By the State Department," Eldon Advertiser, February 20, 1930.

33. "Story of the Great Osage Dam", 11.

During the next few decades, the area quickly grew as ambitious entrepreneurs established resorts, motor court motels, lodges, summer houses, and other businesses in key locations at the Lake of the Ozarks. Today more than five million visitors travel to the area each year to enjoy the lake's varied attractions. Relocated U.S. Route 54 and the Grand Glaize Bridge provided a direct link to the Lake of the Ozarks allowing the formerly remote region to prosper into a major tourist destination.[34]

III. The Bridge

A. Cantilevered Deck Construction

Union Electric Company and the Missouri State Highway Department, aware of the area's scenic beauty, chose Sverdrup and Parcel's "upside down" configuration for the Grand Glaize crossing so that the bridge's web of trusses would not interfere with travelers' views of the lake. By choosing this type of structure, the highway department departed substantially from its typical through and pony truss bridge designs.

Deck trusses were never very common in Missouri and only six currently remain. Of these six, three employ cantilevered construction and the other three are simply supported.[35] Clayton Fraser of FRASERdesign explained the difference between

34. Callison, 11.

35. Clayton Fraser, "Grand Glaize Bridge. Preliminary Determination of NRHP Eligibility for the Missouri Historic Bridge Inventory," January 22, 1993.

cantilever and simply supported trusses in the historical documentation for the Catfish Creek Bridge in Dubuque County, Iowa:

> Although unusual in Iowa, the cantilevered truss of the Catfish Bridge conformed with general engineering practice. The technique of building out from either end of a bridge and joining at the middle is an ancient one. In principle a cantilevered beam or truss distributes stresses in much the opposite way as does a comparable simply supported structure. Held aloft at both ends by piers or abutments, a simply supported bridge deflects downward toward the middle when loaded so that the lower chord is convex under a positive bending moment. A cantilevered bridge, on the other hand, is supported at only one end and must therefore be counterbalanced by a second member extending in the opposite direction from the pier. A cantilever span bends so that the upper surface is convex in a state of negative bending. The distribution of tensile and compressive forces is therefore reversed. In a simple truss the top chord is in compression and the bottom in tension; the top chord of a cantilever truss is in tension and the bottom chord in compression[36].

Charles Shaler Smith engineered this nation's first large-scale cantilever bridge in the United States which was the Kentucky River Bridge of the Cincinnati Southern Railroad built in 1876-77. Others, built with increasingly longer spans, followed. The Missouri State Highway Department had limited experience with cantilevered deck construction until the Grand Glaize Bridge was designed in 1929. This upside down configuration perfectly suited the Lake of the Ozarks and so the same design was chosen for two other bridges spanning the lake in Camden County. The Camden County court, with the help of federal

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36. Clayton Fraser, "Historical Documentation. Catfish Creek Bridge, Dubuque County, Iowa", submitted to Iowa Department of Transportation, Ames, Iowa, December, 1993.

funds, built the Hurricane Deck Bridge in 1935 across the Osage Arm of the Lake of the Ozarks. The following year, the State Highway Department built another cantilever deck bridge over the lake's Niangua Arm. Sverdrup and Parcel, Consulting Engineers of St. Louis, designed each of these cantilever deck truss bridges and to date, all three remain.[37]

B. Bridge Description

(see HAER Field Notes for construction drawings)

The Grand Glaize Bridge (Bridge No. J-832) spanning the Grand Glaize arm of the Lake of the Ozarks consists of three rigid-connected 360 foot cantilevered deck truss spans alternating between four 120 foot suspended deck truss spans, and two 35 foot I-beam stringer approach spans. The total length of the bridge is 1,630 feet. It has a 20 foot roadway width. From east to west the substructure members are designated Abutment 1, Bent 2, Piers 3 through 8, Bent 9, and Abutment 10. All are built of reinforced concrete and are set in bedrock. The spans are numbered consecutively from 1 through 9.

Abutments 1 and 10 are open abutments. Of the two, Abutment 10 is of a slightly larger dimension. Each abutment consists of two rectangular footings supporting front-battered columns spaced 20 feet apart at their centers. Column heights are 5 feet 11 inches for Abutment 1, and 11 feet 11 inches for Abutment 10.

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37. Fraser, "Historical Documentation," and "Preliminary Determination of Eligibility,"; M.S.H.D., Bridge No. J-832 File, Chief Engineer to Beverly Eddings, July 7, 1971.

The columns support a cap beam forming the bridge seat at a grade elevation of 696.5 feet. The backwall and wings are 38 feet 6 inches in length.

Bents 2 and 9 are pedestal bents, each composed of paired square footings and battered columns, with Bent 2 having larger dimensions. The column heights are 7 feet 6 inches for Bent 2, and 3 feet 6 inches for Bent 9. Each has a 3 foot square beveled top, set at an elevation of 677.5 feet. The column centers are spaced 15 feet apart. These bents support the lower truss members of the end spans.

The I-beam stringer approach spans are supported by the two abutments and the upper members of the end spans. The approach spans are each 35 feet long. They consist of four 24 inch I-beam stringers bolted to plate and sole bearings on the bridge seat and braced with angle cross braces. They support 8 inch I-beam cross beams.

Piers 3 through 8 are spill-through dumbbell piers of similar design but of varying dimensions. Each has a rectangular footing measuring 15 by 30 by 18 feet. The footings support two battered, cylindrical columns spaced 15 feet apart at their centers, with basal dimensions ranging from 10 feet 5 inches to 10 feet 9 inches. Column heights range from over 89 feet (Pier 8) to over 93 feet (Pier 4). The columns are connected with upper web walls above the 630 foot elevation, and are capped with 2 foot thick copings. The elevations of the tops of the piers

range from 664.2 feet at the two end piers to 665.9 feet at the two center piers.

The three 360 foot cantilevered deck truss spans each consist of twelve panels, with a normal panel length of 30 feet. In each span, the upper chord consists of two channels with end tie plates and intermediate tie plates. The inclined end posts and lower chord are of two built-up channels (four angles) with double lacing, intermediate tie plates, and end tie plates. Diagonal web members consist of 12 inch I-beams for the tension members, while compression members are two built-up channels (four angles) or two channels, with double lacing and end tie plates. Vertical members are 12 inch I-beams. Splice plate connections occur at the panel points. Diagrams of four angles, gusset plates, and pin plates occur at the end panel points where eye bars and pins connect the cantilever arms with the suspended spans. The bearing devices consist of both fixed and expansion bearings. Finger-type expansion devises, partition joints, and contraction joints occur at the span connections and second panels.

The 120 foot suspended spans consist of six panels, each with a panel length of 20 feet. In each span, the upper chord consists of two channels with double lacing, end tie plates, and intermediate tie plates. The lower chord and inclined end posts are two channels with end tie plates and intermediate tie plates. Vertical and diagonal web members are I-beams. Panel point connections are similar to those of the cantilever spans.

Lateral bracing of the cantilever spans' upper chords consist of two-angle struts and two-angle laterals. Bottom laterals consist of four-angle struts with double lacing and tie plates, and laterals of two angles with double lacing and tie plates. Lateral bracing of the suspended spans employs single angles on both the upper and lower chords.

Sway bracing of the cantilever spans consists of two angles at alternate panels. The portal bracing consists of two angles with double lacing and tie plates. The sway braces of the suspended spans consist of single angles.

The floor system consists of 24 inch I-beam floor beams at the panel points; three I-beam stringers; and 8 inch I-beam cross beams with eight per panel on the cantilever spans and five per panel on the suspended spans. The bridge has reinforced concrete flooring and curbs, with two-angle handrail posts and pipe handrails.

IV. Contractors

A. Sverdrup and Parcel, Consulting Engineers

Leif J. Sverdrup, founder of Sverdrup and Parcel, was born in Norway in 1898 and immigrated to the United States at the age of sixteen. He received a B.A. degree from Minnesota's Augsburg College in 1918, served briefly in the U.S. Army field artillery, then in 1919 entered the University of Minnesota to study civil engineering. Following his graduation, Sverdrup joined the fledgling Missouri State Highway Department in 1922 where he

worked as a bridge designer. During 1923 he became the project engineer for the department's Mount Sterling bridge in Gasconade County. This experience led to his promotion to Bridge Engineer on January 1, 1924, a position in which he directly supervised bridge construction across the state. By January 1926, he was the Assistant to the Chief Engineer.[38]

Despite his rapid rise in the highway department, Sverdrup was anxious to begin his own consulting firm. In January 1927, Sverdrup approached a group in Hermann, Missouri, led by Gasconade County Circuit Judge Ransom Breuer, who had recently formed a committee to pursue the construction of a highway bridge over the Missouri River. Sverdrup offered to design and supervise the construction of their proposed bridge in return for a 7 percent fee. The bridge committee accepted his offer in March. In July, Sverdrup invited his former teacher, John I. Parcel, to form a partnership as engineering consultants and to help in the design of the Hermann bridge. Parcel, a professor of structural engineering at the University of Minnesota since 1909, agreed to the offer although he retained his teaching position at the university.[39]

The firm of Sverdrup and Parcel was officially founded on April 1, 1928. Later that month Sverdrup also accepted the

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38. Gregory Franzwa, Legacy: The Sverdrup Story (St. Louis: Sverdrup Corporation, 1978), pp. 1-4; Gregory Franzwa and William J. Ely, Leif Sverdrup, Engineer Soldier at His Best (Gerald, Missouri: Patrice Press, 1980), pp. 1-31.

39. Ibid., pp. 32-36.

position as vice-president and general manager of the National Toll Bridge Company of New York. Sverdrup and Parcel then signed the Hermann bridge contract which allowed their firm to design the bridge while its construction and subsequent ownership fell under the control of the National Toll Bridge Company. With his new business underway, Sverdrup left his job at the Missouri State Highway Department.[40]

Sverdrup and Parcel opened their office in St. Louis in June 1928, with a small engineering staff comprised of former Missouri Highway Department employees and completed their design of the Hermann bridge. Their next job came in August 1929, when Sverdrup and Parcel secured a contract to design a Missouri River bridge at Nebraska City, Nebraska; later they contracted with the Missouri Highway Department to design the Grand Glaize Bridge over the emerging Lake of the Ozarks in central Missouri.[41]

This work barely kept the new company afloat. Parcel had returned to the University of Minnesota in September 1929, after a year's leave of absence, and Sverdrup had difficulties meeting monthly payrolls. Thus in late 1930 Sverdrup was eager to secure additional business both for his own firm and, presumably, for the National Toll Bridge Company. It appears likely that he sought out Judge Breuer in late August at the time of the dedication of the Hermann bridge. By early November, Sverdrup had joined with Breuer and other locally prominent men to form

40. Ibid., pp. 38-40.

41. Ibid., pp. 41-45.

the Gasconade Bridge Company with the expressed purpose of building a toll bridge over the Gasconade River. Sverdrup invested $1,000 in the company's stock, and at the same time resigned his position with the National Toll Bridge Company.[42]

After the Gasconade bridge project, Sverdrup and Parcel continued to obtain an increasing number of commissions, including several more bridge projects in Missouri. The growing success of the firm led Parcel to resign his teaching position and become a full-time partner in June 1936. Sverdrup and Parcel also did work for the U.S. Army Corps of Engineers in the Midwest and along the west coast. It was his connection to the Corps which led Sverdrup to the South Pacific theater during World War II, where he was commissioned Colonel in the Army Corps in 1942, eventually becoming a Major General. After the war Sverdrup and Parcel, using their government connections, grew to become a prestigious international engineering firm, designing and constructing numerous extensive projects such as the trans-Arabian oil pipeline in 1947 and the U.S. Air Force's Arnold Engineering Development Center in 1950. The firm reorganized in 1977 into Sverdrup Corporation, comprised of four divisions including Sverdrup and Parcel and Associates specializing in planning, architecture, and engineering.[43]

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42. Ibid., p. 41; Hermann, Missouri, Advertiser Courier, August 29, November 7, 1930.

43. Franzwa, Legacy, pp. 24-43, 187-189; Justin L. Faherty, David R. Brown, and Mary Kimbrough, Movers and Shakers: Men Who Have Shaped St. Louis (Tuscon: Patrice Press, 1992), pp. 9-11; McCune Gill, The St. Louis Story, 3 vols. (St. Louis: Historical Record Association, 1952), 3:1136.

B. Pioneer Construction Company

The Pioneer Construction Company, the general contractor for the Grand Glaize Bridge, was incorporated in 1918. The Kansas City-based company formed to design and build major engineering structures such as bridges, highways, dams, reservoirs, and railways.

Frederick R. Hoover, the company's president and major shareholder, already had an established history of construction in Kansas City and the Midwest when he founded the company at age 42. His father, Joseph Warren Hoover, was a bridge builder known from the Mississippi River to Colorado and had worked as a civil engineer in offices in Indianapolis and Canton, Ohio. He settled in Kansas City in 1884 when the Wrought Iron Bridge Company of Canton, Ohio moved its headquarters there and changed its name to Canton Bridge Company. Frederick followed in his father's path by studying civil engineering at the University of Michigan. After his graduation in 1899, he returned to Kansas City and found employment with the Canton Bridge Company where he worked closely with his experienced father.[44]

After years of valuable training, Fred Hoover left the Canton Bridge Company in 1918 to establish the Pioneer Construction Company. In addition to the Grand Glaize Bridge,

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44. Pioneer Construction Company, File. Corporations Division, Secretary of State, Missouri State Information Center: Jefferson City; Carrie Westlake Whitney, Kansas City Missouri. Its History and Its People, 1800-1908, 2 vols. (Chicago: The S.J. Clarke Publishing Company, 1908), 2:396-399.

Pioneer Construction Company was the general contractor for several bridges, mostly minor crossings, throughout Missouri. Among those bridges are the Grand River Bridge in Davies County, built in 1930, and the bridge over the Platte River in Buchanon County, built in 1924. Hoover's company remained in operation until December 1952 when the company dissolved. When the Pioneer Construction Company ceased to operate, Fred Hoover was 76 years old and was still president and sole shareholder for the company he had founded.[45]

C. Stupp Brothers Bridge and Iron Company

When Stupp Brothers Bridge and Iron Company designed the superstructure for the Grand Glaize Bridge, the company was one of Missouri's leading suppliers of bridge components.[46] This company grew out of the South St. Louis Iron Works founded in 1856 by John Stupp, a German immigrant. Stupp's iron works manufactured a wide variety of iron products, including ornamental fences, gates, steam engines, boilers, presses, and architectural detailings. During the Civil War Stupp provided armor plating for Union gunboats. In 1879 Stupp's three sons--George, Peter, and Julius--entered into the business and began to design, fabricate, and erect bridges for city and county roads

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45. Pioneer Construction Company, File; Bridge File Index, (Jefferson City: Bridge Division, Missouri Highway and Transportation Department).

46. Franzwa, Legacy, p. 14.

and railways.[47] In 1886 the works relocated to 7th and Shenandoah Streets in St. Louis. Stupp Brothers Bridge and Iron Company was incorporated in 1890, with George Stupp as President, Peter Stupp as Vice President, and Julius Stupp as Secretary. By the turn of the century the company was involved in the manufacture of wrought iron and steel parts for bridges and buildings throughout the western and southwestern United States, erecting structures under contract or supplying other firms with ready-made steel and iron components. The works in St. Louis by then employed about eighty mechanics, while the company had branch offices in Kansas City, Missouri, and Iowa City, Iowa.[48]

In 1903, the company moved its plant to a more extensive site in southeastern St. Louis County and continued to expand its capabilities in various aspects of structural steel construction. During World War I the company fabricated steel for defense plants and supplied parts for Liberty ships. Stupp Brothers operated a boat yard during World War II where landing craft and floating dry docks were assembled. The company expanded in 1952 with the establishment of a subsidiary, Stupp Corporation in Louisiana, manufacturer of steel pipe for fuel lines and construction pilings. Since then, Stupp Brothers has been involved in the engineering and fabricatcn of steel for major industrial, commercial, transportation, and public works projects

47. "Stupp Bros. Bridge and Iron Co.," (St. Louis: Stupp Bridge and Iron Co., ca. 1987), brochure.

48. E. D. Kargau, Mercantile, Industrial, and Professional St. Louis (St. Louis: Nixon-Jones Printing Co., 1902), p. 311.

worldwide.[49] The company now employs 550 people, with annual sales in 1992 of $119 million. The fifth generation of the Stupp family serves on the company's Board of Directors.[50]

D. C. P. O'Reilly Construction Company

The C. P. O'Reilly Construction Company of St. Louis built the approaches for the Grand Glaize Bridge. Unfortunately, little information on this company is available. The earliest reference to O'Reilly identifies him in 1898 as the manager of the Grant Quarry Company at 921 Chestnut Street in St. Louis.[51] Five years later O'Reilly headed C. P. O'Reilly and Company, a railroad contracting firm, at the same address.[52] By 1917, O'Reilly was listed as a general contractor,[53] and in 1926 he headed a road contracting company.[54] The following year his company built the east approach of the Mississippi River bridge at Cape Girardeau. Thus, O'Reilly had over thirty years of experience in the construction trade by the time of his involvement with the Grand Glaize Bridge. His company continued until 1932 when apparently

49. "Stupp Bros.," brochure.

50. Dun and Bradstreet, Million Dollar Directory: America's Leading Public and Private Companies, (N.p., Dun and Bradstreet, 1993).

51. Gould's St. Louis Directory: 1898, (St. Louis: Gould Directory Company, 1898).

52. Ibid., 1903.

53. Gould's Directory of Public Officers and Institutions for 1917, (St. Louis: Polk-Gould Directory Company, 1917).

54. Gould's St. Louis Directory, 1926.

it succumbed to the Great Depression; the 1933 city directory listed O'Reilly simply as a laborer.[55]

55. Ibid., 1932, 1933.

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